

## Claims

1. White particles used for image display media in an image display device, in which the image display media are sealed between opposed substrates, at least one of two substrates being transparent,  
5 and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that the white particle comprises a center portion and an outer portion coating the center portion, wherein the center portion has a total reflectance of not less than 70 % at a boundary between the center  
10 portion and the outer portion, and, wherein the outer portion is formed by at least one resin layer, in which fine particles made of a high reflectance material are mixed with a low reflectance material.
2. The white particles according to claim 1, wherein the center portion is a solid metal particle or a hollow metal particle.
- 15 3. The white particles according to claim 2, wherein the center portion is a particle in which a metal film is coated on the resin layer.
4. The white particles according to claim 1, wherein the boundary between the center portion and the outer portion is a reflection film formed by a multi-layer film.
- 20 5. The white particles according to one of claims 1 - 4, wherein a diameter of the center portion is 50 - 95 % with respect to a particle diameter.
6. The white particles according to one of claims 1 - 5, wherein an average particle diameter  $d(0.5)$  is 0.1 - 50  $\mu\text{m}$ .
- 25 7. The white particles according to one of claims 1 - 6, wherein the resin layer of the outer portion has a surface of the outer portion has a surface to which a coupling agent treatment is performed.
8. The white particles according to one of claims 1 - 6, wherein the resin layer of the outer portion has a surface coated by a  
30 transparent resin having a strong electrostatic property.
9. White liquid powder characterized in that use is made of the white particles set forth in one of claims 1 - 8.
10. An image display device, in which the image display media

are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that, as at least one group of the image display media, use is made of the white particles set forth in one of claims 1 - 8 or the white liquid powder set forth in claim 9.

11. Particles used for an image display media, characterized in that: in an image display panel, in which at least two groups of image display media having different colors and different charge characteristics are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image; at least two groups of the image display media having different colors and different charge characteristics are constructed by at least three groups of particles including two groups of substantially circular particles having different color and different charge characteristics and third particles having a diameter smaller than that of the two groups of substantially circular particles.

12. The particles used for the image display media according to claim 11, wherein the two groups of substantially circular particles having different colors and different charge characteristics have an average particle diameter in a range of 0.5 - 50  $\mu\text{m}$  and have substantially same average particle diameter with each other.

13. The particles used for the image display media according to claim 11 or 12, wherein a surface of the two groups of substantially circular particles having different colors and different charge characteristics is macroscopically smooth.

14. The particles used for the image display media according to one of claims 11 - 13, wherein the third particles have a substantially circular shape.

15. The particles used for the image display media according to one of claims 11 - 14, wherein an average particle diameter of the third particles is 20 - 200 nm.

16. An image display panel in which use is made of the image display media using the particles set forth in one of claims 11 - 15, characterized in that at least two groups of the image display media filled between the substrates have a volume occupying rate in a range  
5 of 5 - 70 vol %.

17. An image display device characterized in that the image display panel set forth in claim 16 is installed.

18. Particles used for image display media of an image display device, in which at least two groups of the image display media having  
10 charge characteristics and made of color particles are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field generated between two electrodes having different potentials is applied, are made to move so as to display an image, characterized in that the  
15 particles are made of a low dielectric insulation material.

19. Particles used for image display media of an image display device, in which one group of the image display media having charge characteristics and made of color particles are sealed between opposed substrates, at least one of two substrates being transparent, and in  
20 which the image display media, to which an electrostatic field generated between two electrodes having different potentials is applied, are made to move so as to display an image, characterized in that the particles are made of a low dielectric insulation material.

20. The particles used for the image display media according to  
25 claim 18 or 19, wherein the particles have a specific inductive capacity  $\epsilon_r$  of  $\epsilon_r \leq 5.0$ .

21. The particles used for the image display media according to claim 20, wherein the particles have a specific inductive capacity  $\epsilon_r$  of  $\epsilon_r \leq 3.0$ .

30 22. The particles used for the image display media according to one of claims 18 - 21, wherein high dielectric filler is not contained in the particles and conductive filler is not contained in the particles.

23. The particles used for the image display media according to

one of claims 18 - 22, wherein high dielectric material is not adhered to a surface of the particles and high conductive material is not adhered to a surface of the particles.

24. The particles used for the image display media according to one of claims 18 - 23, wherein an average particle diameter of the particles is 0.1 - 50  $\mu\text{m}$ .

25. The particles used for the image display media according to one of claims 18 - 24, wherein a surface charge density of the particles is 5 - 150  $\mu\text{C}/\text{m}^2$  in an absolute value.

26. An image display device characterized in that use is made of the particles used for the image display media according to one of claims 18 - 25.

27. White particles used for an image display device, in which image display media are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that the white particles are made of secondary particles produced by agglutinating or granulating primary particles of white pigment coated by a binder, and the white particles have fine bubbles therein.

28. The white particles according to claim 27, wherein the white pigment is titanium oxide.

29. The white particles according to claim 27 or 28, wherein the binder is made of a material having a low refraction index.

30. The white particles according to one of claims 27 - 29, wherein the agglutinating or granulating step of the primary particles is performed by mixing and agitating in a flowing gas current or mechanically so as to introduce a lot of fine bubbles.

31. The white particles according to one of claims 27 - 30, wherein an average particle diameter  $d(0.5)$  is 0.1 - 50  $\mu\text{m}$ .

32. White liquid powder characterized in that use is made of the white particles set forth in one of claims 27 - 31.

33. An image display device, in which image display media are

sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that, as at least one group of the image display media, use is made of the white particles set forth in one of claims 27  
5 - 31 or the white liquid powder set forth in claim 32.

34. Particles used for image display media in an image display panel, in which at least two groups of the image display media are sealed between opposed substrates, at least one of two substrates being  
10 transparent, and in which the image display media, to which an electrostatic field generated between two electrodes having different potentials is applied, are made to move so as to display an image, characterized in that one of the two groups of the particles having different charge characteristics and different optical reflectance  
15 included in the at least two groups of the image display media has a surface on which macroscopic concavo-convex portion exists, and the other of the two groups of the particles has a surface on which no macroscopic concavo-convex portion exists.

35. Particles used for image display media in an image display  
20 panel, in which at least two groups of the image display media are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field generated between two electrodes having different potentials is applied, are made to move so as to display an image,  
25 characterized in that one of the two groups of the particles having different charge characteristics and different optical reflectance included in the at least two groups of the image display media has a surface on which macroscopic concavo-convex portion exists, and the other of the two groups of the particles has a surface on which no  
30 macroscopic concavo-convex portion exists and on which fine particles are adhered in an electrostatic manner.

36. The particles used for the image display media according to claim 34 or 35, wherein, among the two groups of the particles having

different charge characteristics and different optical reflectance, the particles having the surface, on which the macroscopic concavo-convex portion exists, are obtained by crushing a resin agglomerate.

37. The particles used for the image display media according to  
5 claim 34 or 35, wherein, among the two groups of the particles having different charge characteristics and different optical reflectance, the particles having the surface, on which the macroscopic concavo-convex portion exists, are obtained by firmly adhering fine particles on a surface of mother particles.

10 38. The particles used for the image display media according to claim 37, wherein the adhering between the mother particles and the fine particles is performed by utilizing a mechanical impact strength.

39. The particles used for the image display media according to  
15 one of claims 34 - 38, wherein, among the two groups of the particles having different charge characteristics and different optical reflectance, the particles having the surface, on which no macroscopic concavo-convex portion exists, are substantially circular particles obtained by polymerizing a resin monomer.

40. The particles used for the image display media according to  
20 one of claims 34 - 38, wherein, among the two groups of the particles having different charge characteristics and different optical reflectance, the particles having the surface, on which no macroscopic concavo-convex portion exists, are substantially circular particles obtained by smoothing the surface under such a condition that crushed particles are  
25 exposed at a temperature higher than a melting point of the particles.

41. The particles used for the image display media according to  
claim 35, wherein, among the two groups of the particles having  
different charge characteristics and different reflectance, the fine  
particles adhered to the surface of the particles, on which no  
30 macroscopic concavo-convex portion exists, have a reverse charge polarity with respect to a charge polarity of the particles having the surface, on which no macroscopic concavo-convex portion exists, and, the fine particles do not change a charge polarity of the particles

having the surface, on which no macroscopic concavo-convex portion exists, after adhered.

42. The particles used for the image display media according to one of claims 34 - 41, wherein an average particle diameter of the two  
5 groups of the particles having different charge characteristics and different optical reflectance is 0.5 - 50  $\mu\text{m}$ .

43. The particles used for the image display media according to claim 41 or 42, wherein an average particle diameter of the fine  
10 particles adhered in an electrostatic manner to the surface of the particles, on which no concavo-convex portion exists, is 20 - 200 nm.

44. An image display panel characterized in that use is made of the image display media utilizing the particles set forth in one of claims 34 - 43, and a volume occupying rate of the at least two groups of the image display media filled between the substrates is in a range  
15 of 5 - 70 vol %.

45. An image display device characterized in that the image display panel set forth in claim 44 is installed.

46. White particles used for an image display device, in which image display media are sealed between opposed substrates, at least  
20 one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that white pigment and hollow particles are filled in a base resin.

47. The white particles according to claim 46, wherein a filling  
25 amount of the white pigment is 100 - 300 parts by weight with respect to 100 parts by weight of the resin and a filling amount of the hollow particles is 10 - 60 parts by weight with respect to 100 parts by weight of the resin.

48. The white particles according to claim 46 or 47, wherein the  
30 white pigment is one of titanium oxide, zinc oxide and zirconium oxide.

49. The white particles according to one of claims 46 - 48, wherein a composition of the hollow particles is a cross-linking

styrene-acrylic.

50. The white particles according to one of claims 46 - 49, wherein an average particle diameter  $d(0.5)$  is 1.0 - 50  $\mu\text{m}$ .

51. White liquid powder characterized in that use is made of the  
5 white particles set forth in one of claims 46 - 50.

52. An image display device, in which image display media are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an  
10 image, characterized in that, as at least one group of the image display media, use is made of the white particles set forth in one of claims 46 - 50 or the white liquid powder set forth in claim 51.

53. Particles used for image display media in an image display device, in which the image display media are sealed between opposed  
15 substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that use is made of a thermosetting resin as a base resin of the particles constituting the image display media, which is obtained by  
20 mixing a resin material including a thermosetting resin, effecting a cross-linking reaction by heat and crushing the bridged resin material.

54. The particles used for the image display media according to claim 53, wherein, as the thermosetting resin constituting the base resin, use is made of one of polyester resin + blockisocyanate series,  
25 alkyd resin + melamine hardening agent series, epoxy resin + amine hardening agent series and urea resin + formaldehyde series.

55. The particles used for the image display media according to claim 53 or 54, wherein the particles include organic tin catalyst, pigment and charge control agent other than the thermosetting resin  
30 constituting the base resin.

56. An image display device characterized in that use is made of the particles used for the image display media set forth in one of claims 53 - 55.



57. Particles used for image display media in an image display panel, in which at least two groups of the image display media are sealed between opposed two substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that a particle shape of at least one of two groups of the particles having different charge characteristics and different optical reflectance, which are included in at least two groups of the image display media, is a flat round shape.

58. The particles used for the image display media according to claim 57, wherein the particles having a flat round shape are white particles.

59. The particles used for the image display media according to claim 58, wherein a color material of the white particles having a flat round shape is titanium oxide.

60. The particles used for the image display media according to one of claims 57 - 59, wherein the particles having a flat round shape are formed by crushing a resin sheet to obtain crushed pieces and exposing the crushed pieces at a temperature higher than a melting point of the resin.

61. The particles used for the image display media according to one of claims 57 - 60, wherein an average particle diameter of the two groups of the particles having different charge characteristics and different optical reflectance, which are included in at least two groups of the image display media, is 0.1 - 50  $\mu\text{m}$ .

62. An image display panel utilizing the particles used for the image display media set forth in one of claims 57 - 61, wherein a volume occupying rate of at least two groups of the image display media having different colors and different charge characteristics, which are filled between the substrates, is in a range of 5 - 70 vol %.

63. An image display device characterized in that the image display panel set forth in claim 62 is installed.

64. Particles used for image display media in an image display

panel, in which at least two groups of the image display media including the particles having different colors and different charge characteristics are sealed between opposed two substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that a relation of particle diameters between two groups of the particles having different colors and different charge characteristics contained in the image display media (deep dark color particles and pale bright color particles) is indicated as  $D_{\text{dark}} < D_{\text{bright}}$ , when it is assumed that an average particle diameter of the deep dark color particles is  $D_{\text{dark}}$  and an average particle diameter of the pale bright color particles is  $D_{\text{bright}}$ .

65. The particles used for the image display media according to claim 64, wherein the relation between the average particle diameter  $D_{\text{dark}}$  of the deep dark color particles and the average particle diameter  $D_{\text{bright}}$  of the pale bright color particles is  $1 < D_{\text{bright}}/D_{\text{dark}} < 2$ .

66. The particles used for the image display media according to claim 64 and 65, wherein particles constituting the deep dark color particles are a black color, and particles constituting the pale bright color particles are a white color.

67. The particles used for the image display media according to one of claims 64 - 66, wherein a particle diameter of the deep dark color particles is controlled by effecting an over-cut process utilizing a classification method, and a particle diameter of the pale bright color particles is controlled by effecting an under-cut process utilizing a classification method.

68. The particles used for the image display media according to one of claims 64 - 67, wherein a particle diameter of at least two groups of the particle having different colors and different charge characteristics is in a range of 1 - 50  $\mu\text{m}$ .

69. An image display panel utilizing the particles used for the image display media set forth in one of claims 64 - 68, wherein a

volume occupying rate of at least two groups of the image display media having different colors and different charge characteristics, which are filled between the substrates, is in a range of 5 - 70 vol %.

70. An image display device characterized in that the image display panel set forth in claim 69 is installed.

71. Particles used for image display media in an image display device, in which the image display media are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that metal oxide ( $\text{MO}_x$ : here, M; metal element, O; oxygen, x; O/M ratio) is added in a base resin of the particles constituting the image display media.

72. Particles used for image display media in an image display device, in which the image display media are sealed between opposed substrates, at least one of two substrates being transparent, and in which the image display media, to which an electrostatic field is applied, are made to move so as to display an image, characterized in that fatty acid metal salt compound  $((\text{C}_m\text{H}_n\text{COO})_y\text{M}_z$ : here, M; metal element, m, n, y, z; integer,  $4 < m < 22$ ) is added in a base resin of the particles constituting the image display media.

73. The particles used for the image display media according to claim 71 or 72, wherein a Pauling's electronegativity  $\chi$  of an ion of the metal element (M) is  $0.79 < \chi < 1.91$  and has a positive charge characteristic.

74. The particles used for the image display media according to claim 73, wherein the metal element is one of Mg, Zn, Ca, Li, Zr, Al, Ni, Cu, Ba and Ti.

75. The particles used for the image display media according to claim 71 or 72, wherein a Pauling's electronegativity  $\chi$  of an ion of the metal element (M) is  $1.50 < \chi < 2.58$  and has a negative charge characteristic.

76. The particles used for the image display media according to

claim 75, wherein the metal element is one of Fe, Ti, Cu, Si, Sb, W, Sn, Ge and Co.

77. An image display device characterized in that an image display panel utilizing the image display media constituted by the  
5 particles set forth in one of claims 71 - 76 is installed.